Extending GPS Orbit and Clock Products to High Rate GPS Satellite Clock Solution

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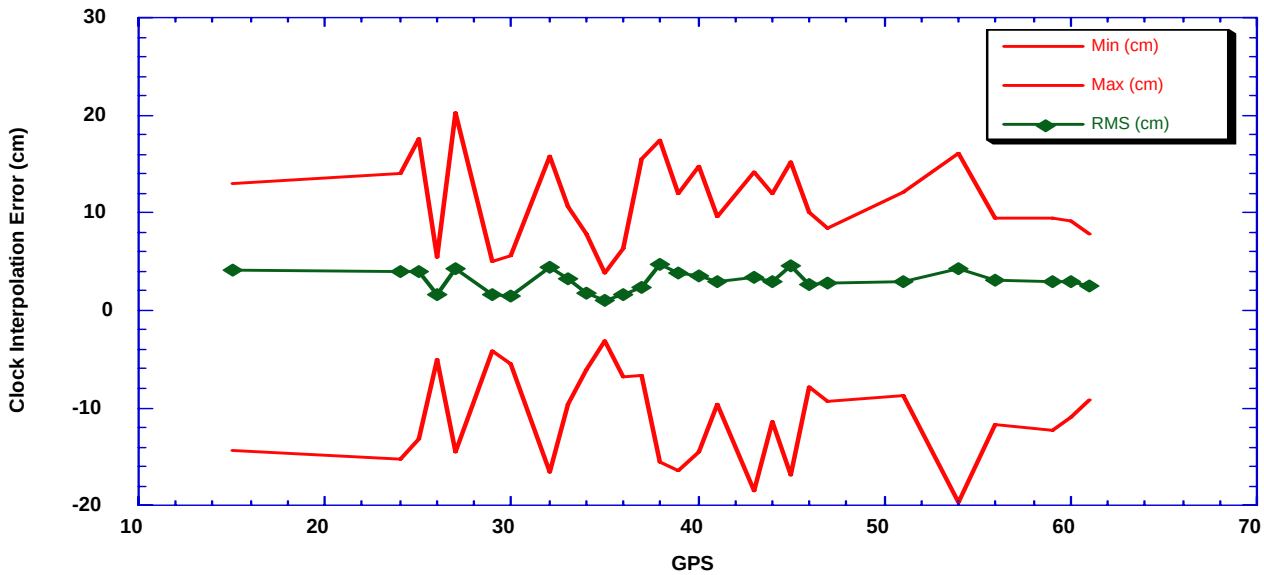
Why High Rate Clock?

- Regular precise GPS orbit and clock solutions at 3 cm level

  -- 15 minute for orbits, 5 minute for clocks

- Scientific studies need precise measurements at higher rates
- Error of interpolating GPS clock between 5 minute points



Solve for High Rate Clock from Phase Data

- Method 1: interpolating station clocks

  -- fix receiver clocks and interpolate between 5 minute points

  -- solve for GPS clocks only, very efficient

  -- only a few stations good for interpolating

- Method 2: network solution

  -- fix reference station clock only

  -- solve other receiver clocks and GPS clocks in network

  -- good data coverage, 99% with 25 stations

Use of Undifferenced Phase Ambiguity

Both methods hold phase biases fixed to their best known values

- For efficiency

-- use phase measurement only

-- otherwise 90% parameters would be phase biases

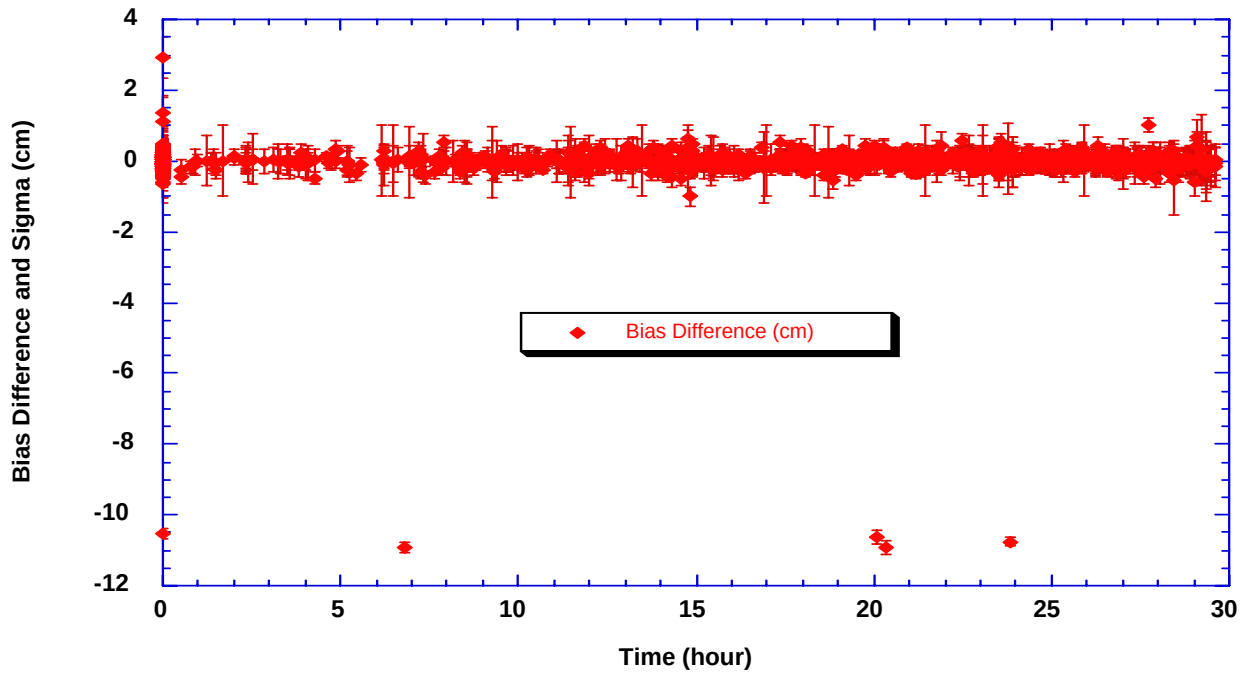
- For accuracy

-- turn phase measurement into range measurement

-- otherwise need pseudorange data which are noisy

How Good Are Phase Bias Parameters?

- If all models are clean, phase biases can be recovered
- Most resolved phase biases agree with previously solved values except a few 2π jumps

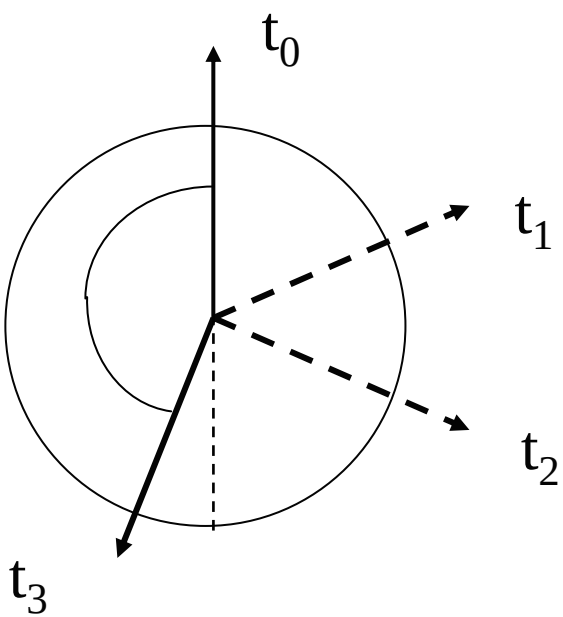


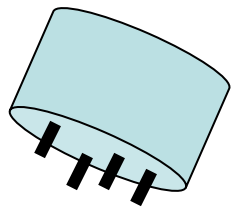
Error Sources from the Phase Data

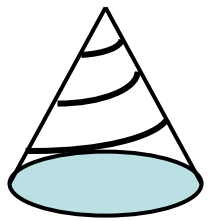
- Mismatch between phase measurement and phase biases
  - -- alignment between 5 min and 30 sec data file
  - -- match between measurement and bias passes
- Mismodeling the phase windup effect
  - -- yaw attitude uncertainty
  - -- windup 2π ambiguity

Windup effect in Phase Bias Parameters

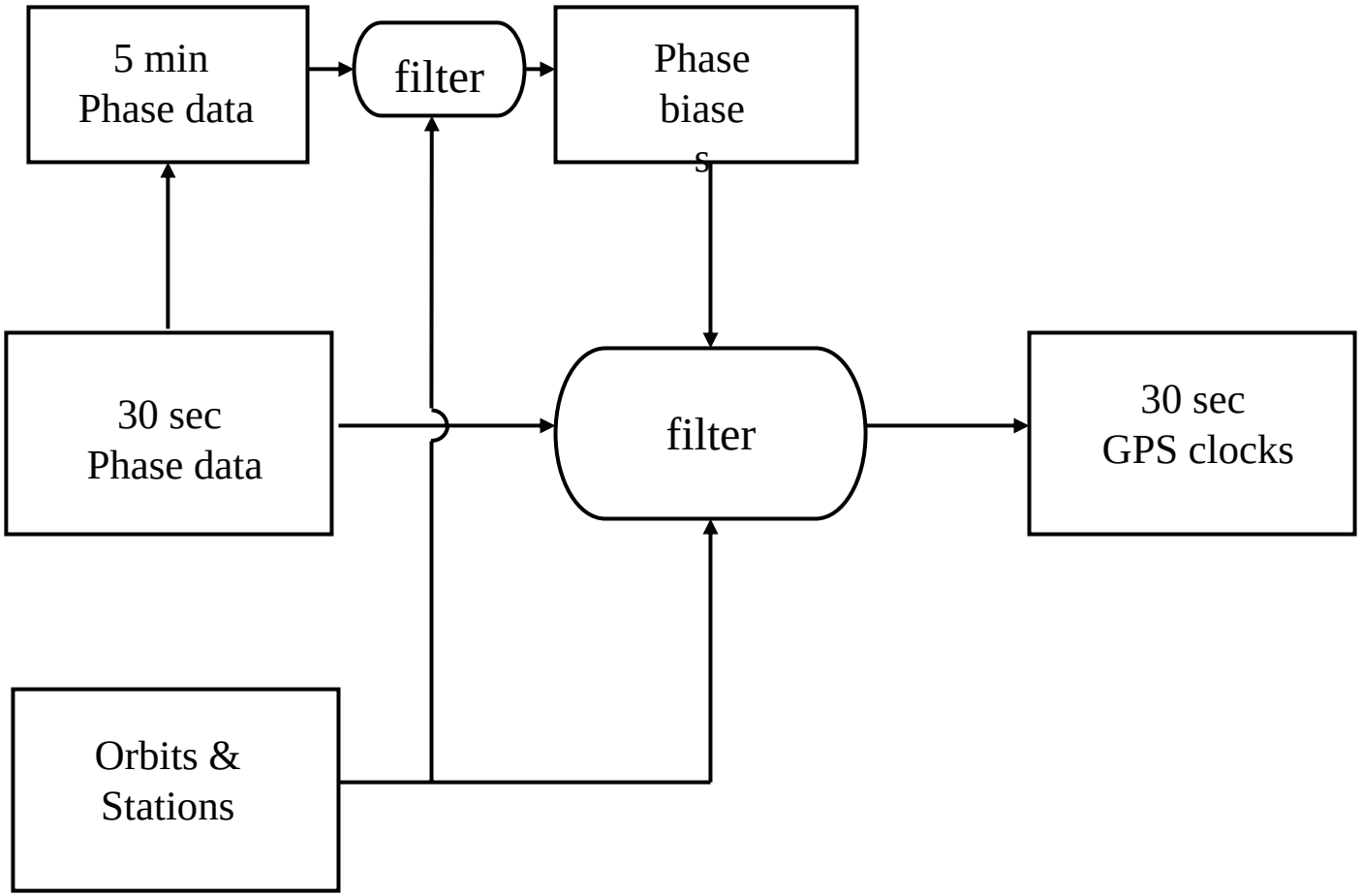
- Windup must match between 5 min and 30 second data
- 2π jumps associated with data gaps







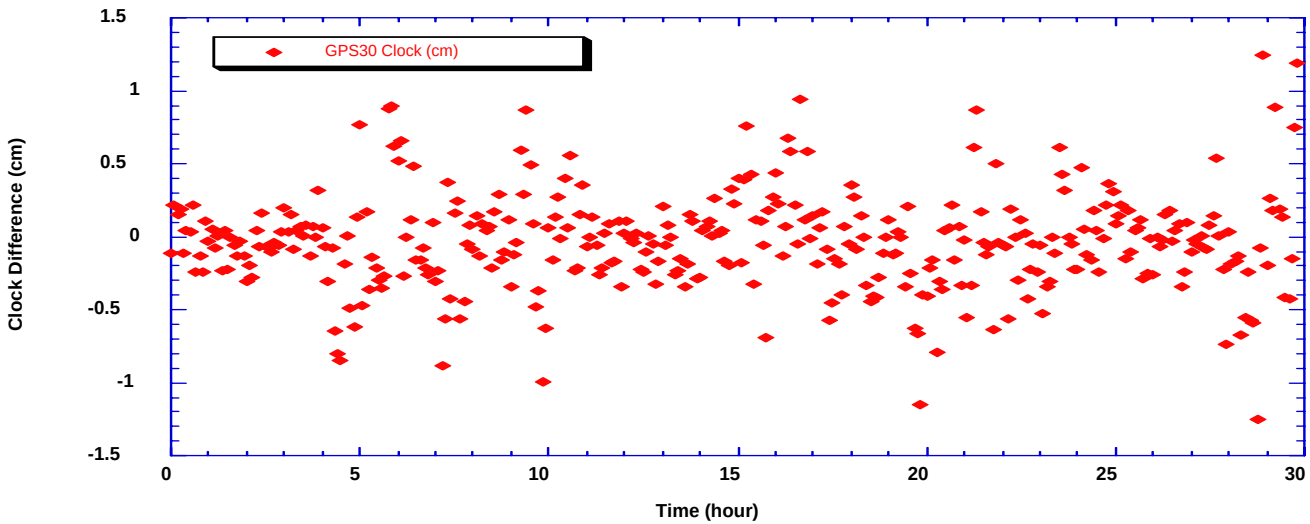
High Rate Clock Solution Process (2)



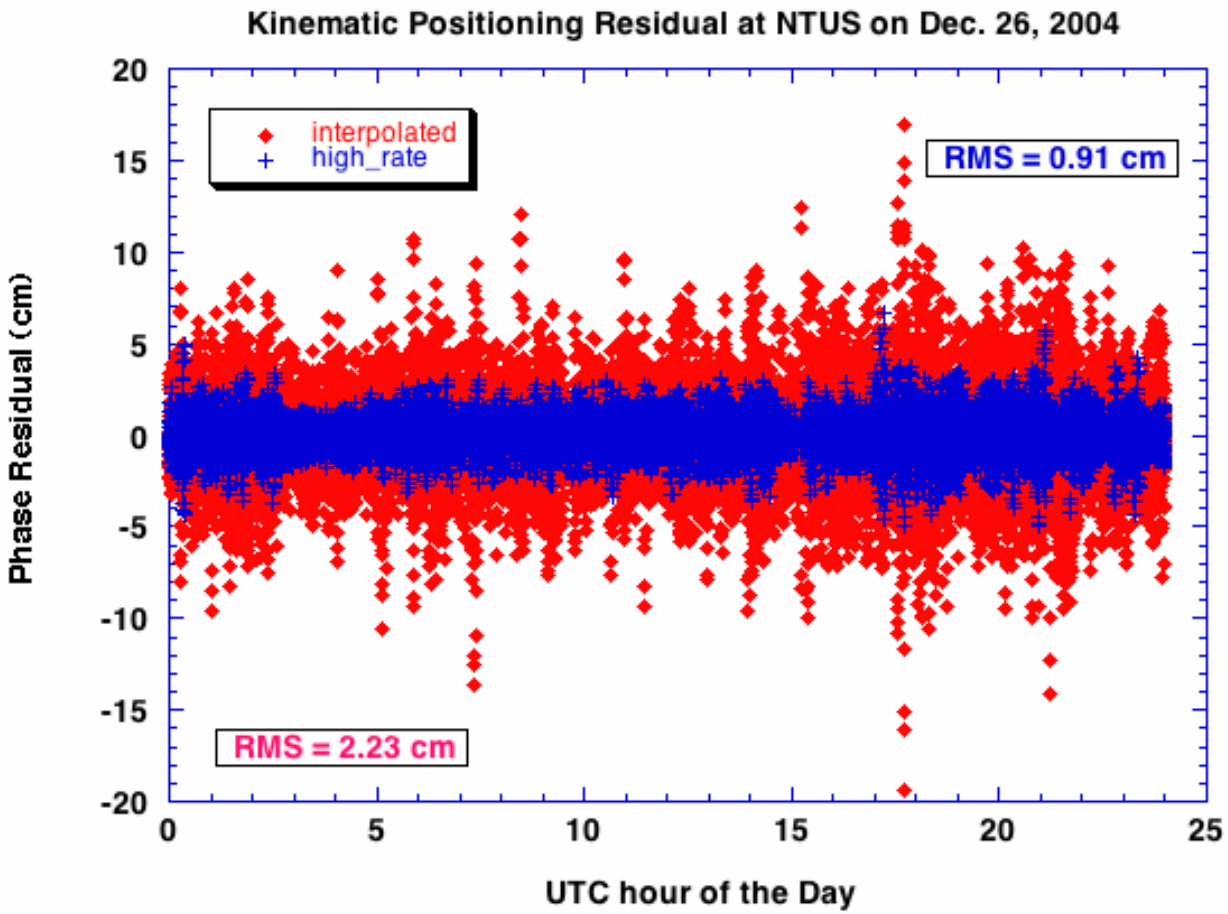
High Rate Clock Solution Evaluation (1)

RMS difference over all 5 minute data points:

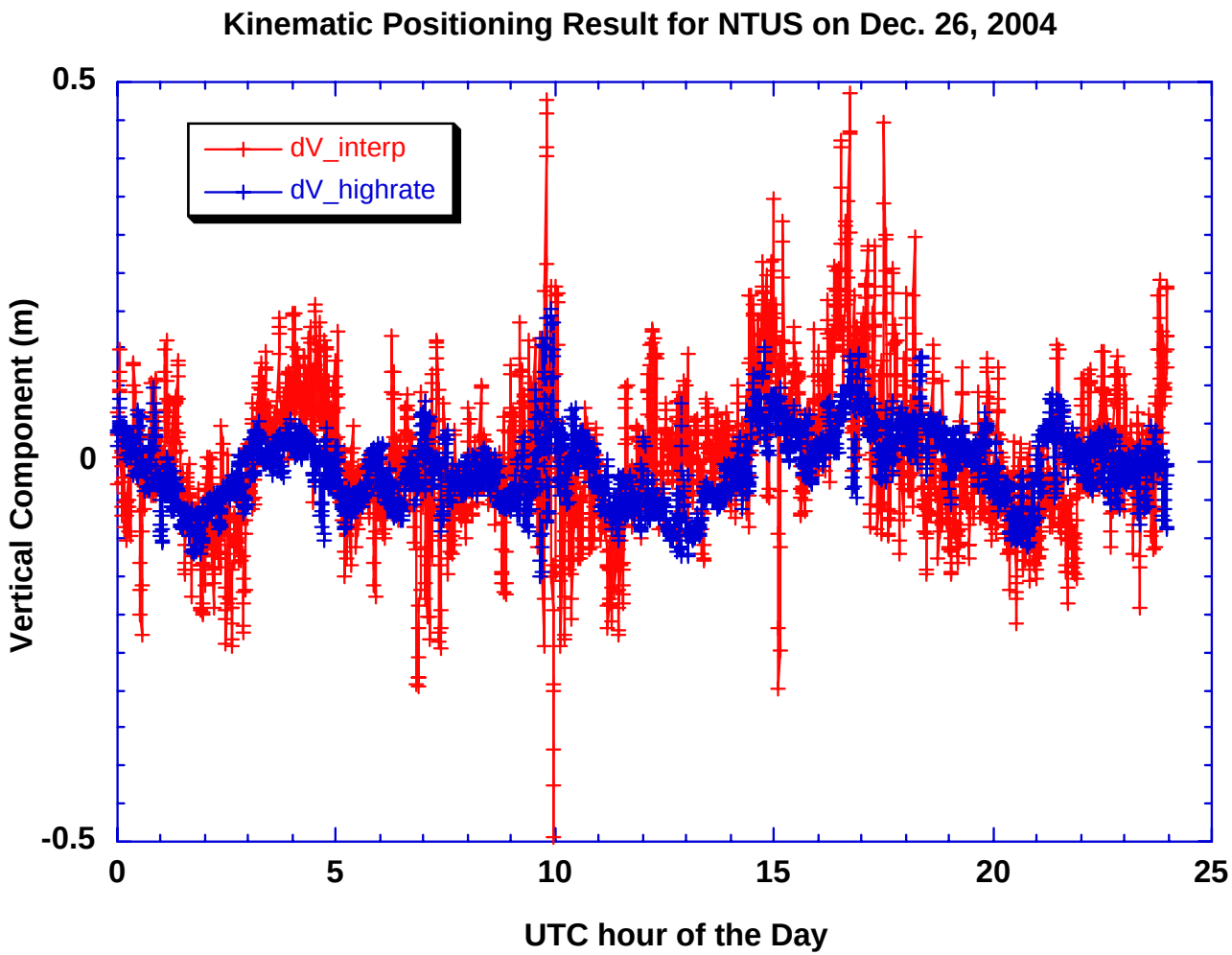
$$RMS = \sqrt{\sum_{Ns}\sum_{Nt}\left(T_h - T_r\right)^2 / \sum_{Ns} Nt} \approx 5mm$$



High Rate Clock Solution Evaluation (2)



High Rate Clock Solution Evaluation (3)



Summary

- 25 global stations recover 99% of 30-second GPS clocks
- 30-second rate GPS clocks at 5 mm level
- Daily JPL solution of 30-second GPS clock solutions at ftp://sideshow.jpl.nasa.gov/pub/gipsy_products/hrclocks